

## **Structurally Stable Flame-Retardant Nonwoven Fabric**

### **Technical Field**

5 The present invention generally relates a hydroentangled flame-retardant nonwoven fabric, and more specifically, to a structurally stable flame-retardant fabric comprising at least two layers, wherein the fibrous components of the fabric have a synergistic relationship so as to maintain the integrity of the flame-retardant fabric upon burning.

### **Background of the Invention**

10 The production of conventional textile fabrics is known to be a complex, multi-step process. The production of fabrics from staple fibers begins with the carding process where the fibers are opened and aligned into a feed stock known as sliver. Several strands of sliver are then drawn multiple times on a drawing frames to further align the fibers, blend, improve uniformity as well as reduce the sliver's diameter. The drawn sliver  
15 is then fed into a roving frame to produce roving by further reducing its diameter as well as imparting a slight false twist. The roving is then fed into the spinning frame where it is spun into yarn. The yarns are next placed onto a winder where they are transferred into larger packages. The yarn is then ready to be used to create a fabric.

20 For a woven fabric, the yarns are designated for specific use as warp or fill yarns. The fill yarns (which run on the y-axis and are known as picks) are taken straight to the loom for weaving. The warp yarns (which run on the x-axis and are known as ends) must be further processed. The large packages of yarns are placed onto a warper frame and are wound onto a  
25 section beam where they are aligned parallel to each other. The section beam is then fed into a slasher where a size is applied to the yarns to make them stiffer and more abrasion resistant, which is required to withstand the weaving process. The yarns are wound onto a loom beam as they exit the slasher, which is then mounted onto the back of the loom. The warp yarns  
30 are threaded through the needles of the loom, which raises and lowers the individual yarns as the filling yarns are interested perpendicular in an interlacing pattern thus weaving the yarns into a fabric. Once the fabric has

been woven, it is necessary for it to go through a scouring process to remove the size from the warp yarns before it can be dyed or finished. Currently, commercial high speed looms operate at a speed of 1000 to 1500 picks per minute, where a pick is the insertion of the filling yarn across the entire width of the fabric. Sheeting and bedding fabrics are typically counts of 80.times.80 to 200.times.200, being the ends per inch and picks per inch, respectively. The speed of weaving is determined by how quickly the filling yarns are interlaced into the warp yarns, therefore looms creating bedding fabrics are generally capable of production speeds of 5 inches to 18.75 inches per minute.

In contrast, the production of nonwoven fabrics from staple fibers is known to be more efficient than traditional textile processes as the fabrics are produced directly from the carding process.

Nonwoven fabrics are suitable for use in a wide variety of applications where the efficiency with which the fabrics can be manufactured provides a significant economic advantage for these fabrics versus traditional textiles. However, nonwoven fabrics have commonly been disadvantaged when fabric properties are compared, particularly in terms of surface abrasion, pilling and durability in multiple-use applications. Hydroentangled fabrics have been developed with improved properties which are a result of the entanglement of the fibers or filaments in the fabric providing improved fabric integrity. Subsequent to entanglement, fabric durability can be further enhanced by the application of binder compositions and/or by thermal stabilization of the entangled fibrous matrix.

U.S. Patent No. 3,485,706, to Evans, hereby incorporated by reference, discloses processes for effecting hydroentanglement of nonwoven fabrics. More recently, hydroentanglement techniques have been developed which impart images or patterns to the entangled fabric by effecting hydroentanglement on three-dimensional image transfer devices. Such three-dimensional image transfer devices are disclosed in U.S. Patent No. 5,098,764, hereby incorporated by reference, with the use of such

image transfer devices being desirable for providing a fabric with enhanced physical properties as well as an aesthetically pleasing appearance.

Heretofore, nonwoven fabrics have been advantageously employed for manufacture of flame-retardant fabrics, as described in U.S. Patent No.

6,489,256, to Kent, et al., which is hereby incorporated by reference.

Typically, nonwoven fabrics employed for this type of application have been entangled and integrated by needle-punching, sometimes referred to as needle-felting, which entails insertion and withdrawal of barbed needles through a fibrous web structure. While this type of processing acts to integrate the fibrous structure and lend integrity thereto, the barbed needles inevitably shear large numbers of the constituent fibers, and undesirably create perforations in the fibrous structure. Needle-punching can also be detrimental to the strength of the resultant fabric, requiring that a fabric have a relatively high basis weight in order to exhibit sufficient strength.

A need exists for a more cost effective flame-retardant nonwoven fabric that is structurally stable, soft, as well as strong and suitable for end-use applications including, but not limited to bedding components, such as mattress covers and other home uses, protective apparel applications, and other industrial end-use applications.

### **Summary of the Invention**

The present invention is directed to a hydroentangled flame-retardant nonwoven fabric, and more specifically, to a structurally stable flame-retardant fabric comprising at least two layers, wherein the fibrous components of the fabric have a synergistic relationship so as to maintain the integrity of the flame-retardant fabric upon burning.

In accordance with the present invention, the nonwoven fabric is comprised of at least a first and second layer. The first layer comprises a blend of lyocell fiber and modacrylic fiber. The fibrous components of the first layer provide the fabric with exceptional strength, in addition to a soft hand. Further, the modacrylic fiber and lyocell fiber form a char rather than melt when burned.

Positioned beneath the first layer is a second layer, comprising a blend of lyocell fiber, modacrylic fiber, and para-amid fiber. As described in the first layer, the lyocell fiber and modacrylic fiber provide the resultant fabric with strength, a soft hand, and form a char as opposed to melting. In addition, the second layer incorporates para-amid fiber, which provides the fabric with structural integrity by maintaining the fibrous structure of the fabric, as well as reducing any thermal shrinkage. Not meaning to be bound by theory, it is believed that the fibrous components of the flame-retardant fabric have a synergistic relationship to provide a cost effective fabric with exceptional strength, softness, and flame retardancy, wherein upon burning, the lyocell fiber forms a char due to the presence of the modacrylic fiber, which also chars, yet the integrity of the fabric remains structurally stable upon the incorporation of the para-amid fiber.

Further, it has been found that the addition of the para-amid fiber in the second layer lends to a discoloration of the fabric, wherein the fabric takes on a yellow hue. The lack of para-amid fiber in the first layer, which is positioned atop the second layer, masks the discoloration of the second layer, improving the aesthetic quality of the fabric.

The first and second layers of the flame-retardant nonwoven fabric are hydroentangled to form a composite fabric comprising the aforementioned fibrous components. Optionally, the nonwoven fabric may be hydroentangled on a three-dimensional image transfer device so as to impart a three-dimensional image or pattern into the fabric, suitably enhancing the aesthetic quality of the fabric for a particular end-use application.

#### **Brief Description of the Drawings**

FIGURE 1 is a diagrammatic view of apparatus utilized in accordance with the present invention so as to manufacture the flame-retardant nonwoven fabric.

#### **Detailed Description**

While the present invention is susceptible of embodiment in various forms, there is shown in the drawings, and will hereinafter be described, a

presently preferred embodiment, with the understanding that the present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated.

5 The flame-retardant nonwoven fabric of the present invention structurally stable, soft, as well as strong and suitable for end-use applications including, but not limited to bedding components, such as mattress covers and other home uses, protective apparel applications, and other industrial end-use applications.

10 U.S. Patent No. 3,485,706, to Evans, hereby incorporated by reference, discloses processes for effecting hydroentanglement of nonwoven fabrics. With reference to FIGURE 1, therein is illustrated an apparatus for practicing the present method for forming a nonwoven fabric. The fibrous components are preferably carded and cross-lapped to form first precursor web, designated P and a second precursor web, designated P', which are hydraulically united to form a composite nonwoven flame-retardant fabric.

20 In one embodiment, a first precursor web is formed comprising staple length lyocell fibers and modacrylic fibers, wherein the modacrylic fibers have an independent level of flame-resistance. Also, a second precursor web is formed comprising staple length fibers of lyocell fibers, modacrylic fibers, and para-amid fibers, wherein the modacrylic fibers, as well as the para-amid fibers have an independent level of flame-resistance. It is also in the purview of the present invention, that other flame-retardant fibers be incorporated in either one or both of the precursor webs, these fibers include, but are not limited to phenolic fibers, such as Kynol™ fiber from American Kynol, Inc., pre-oxidized polyacrylonitrile fibers, such as Panox® fiber, a registered trademark to R.K. Textiles Composite Fibers Limited.

25 Further, FIGURE 1 illustrates a hydroentangling apparatus, whereby the apparatus includes a foraminous forming surface in the form of belt 12 upon which the precursor webs P and P' are positioned for entangling or pre-entangling by manifold 14.

The entangling apparatus of FIGURE 1 may optionally include an imaging and patterning drum 18 comprising a three-dimensional image transfer device for effecting imaging and patterning of the lightly entangled precursor web. The image transfer device includes a moveable imaging surface which moves relative to a plurality of entangling manifolds 22 which act in cooperation with three-dimensional elements defined by the imaging surface of the image transfer device to effect imaging and patterning of the fabric being formed.

In addition to the first and second layers of the flame-retardant nonwoven fabric, it is also contemplated that one or more supplemental layers be added, wherein such layers may include a spunbond fabric. In general, the formation of continuous filament precursor webs involves the practice of the "spunbond" process. A spunbond process involves supplying a molten polymer, which is then extruded under pressure through a large number of orifices in a plate known as a spinneret or die. The resulting continuous filaments are quenched and drawn by any of a number of methods, such as slot draw systems, attenuator guns, or Godet rolls. The continuous filaments are collected as a loose web upon a moving foraminous surface, such as a wire mesh conveyor belt. When more than one spinneret is used in line for the purpose of forming a multi-layered fabric, the subsequent webs are collected upon the uppermost surface of the previously formed web. Further, the addition of a continuous filament fabric may include those fabrics formed from filaments having a nano-denier, as taught in U.S. Patents No. 5,679,379 and No. 6,114,017, both incorporated herein by reference. Further still, the continuous filament fabric may be formed from an intermingling of conventional and nano-denier filaments.

It has been contemplated that the nonwoven fabric of the present invention incorporate a meltblown layer. The meltblown process is a related means to the spunbond process for forming a layer of a nonwoven fabric is the meltblown process. Again, a molten polymer is extruded under pressure through orifices in a spinneret or die. High velocity air impinges

upon and entrains the filaments as they exit the die. The energy of this step is such that the formed filaments are greatly reduced in diameter and are fractured so that microfibers of finite length are produced. This differs from the spunbond process whereby the continuity of the filaments is preserved. The process to form either a single layer or a multiple-layer fabric is continuous, that is, the process steps are uninterrupted from extrusion of the filaments to form the first layer until the bonded web is wound into a roll. Methods for producing these types of fabrics are described in U.S. Patent No. 4,041,203. The meltblown process, as well as the cross-sectional profile of the meltblown microfiber, is not a critical limitation to the practice of the present invention.

In accordance with the present invention, the hydroentangled flame-retardant fabric may comprise a film layer. The formation of finite thickness films from thermoplastic polymers, suitable as a strong and durable carrier substrate layer, is a well-known practice. Thermoplastic polymer films can be formed by either dispersion of a quantity of molten polymer into a mold having the dimensions of the desired end product, known as a cast film, or by continuously forcing the molten polymer through a die, known as an extruded film. Extruded thermoplastic polymer films can either be formed such that the film is cooled then wound as a completed material, or dispensed directly onto a secondary substrate material to form a composite material having performance of both the substrate and the film layers.

Extruded films can be formed in accordance with the following representative direct extrusion film process. Blending and dosing storage comprising at least one hopper loader for thermoplastic polymer chip and, optionally, one for pelletized additive in thermoplastic carrier resin, feed into variable speed augers. The variable speed augers transfer predetermined amounts of polymer chip and additive pellet into a mixing hopper. The mixing hopper contains a mixing propeller to further the homogeneity of the mixture. Basic volumetric systems such as that described are a minimum requirement for accurately blending the additive into the thermoplastic polymer. The polymer chip and additive pellet blend feeds into a multi-zone

extruder. Upon mixing and extrusion from the multi-zone extruder, the polymer compound is conveyed via heated polymer piping through a screen changer, wherein breaker plates having different screen meshes are employed to retain solid or semi-molten polymer chips and other macroscopic debris. The mixed polymer is then fed into a melt pump, and then to a combining block. The combining block allows for multiple film layers to be extruded, the film layers being of either the same composition or fed from different systems as described above. The combining block is connected to an extrusion die, which is positioned in an overhead orientation such that molten film extrusion is deposited at a nip between a nip roll and a cast roll.

In addition, breathable films can be used in conjunction with the disclosed continuous filament laminate. Monolithic films, as taught in U.S. Patent No. 6,191,211, and microporous films, as taught in U.S. Patent No. 6,264,864, both patents herein incorporated by reference, represent the mechanisms of forming such breathable films.

In accordance with the present invention, Sample A comprises a first layer of 60% staple length Tencel® lyocell fibers, Tencel is a registered trademark of Courtaulds Fibres (Holdings) Limited, and 40% PBX® modacrylic fibers, PBX® is a registered trademark to Kaneka, with a basis weight of about 2.0 oz/yd<sup>2</sup> and a second layer comprising a blend of 42% Tencel® lyocell fibers, 37% PBX® modacrylic fibers, and 21% Twaron® para-amid fibers, Twaron is a registered trademark of Enka B.V. Corporation, with a basis weight of about 4.0 oz/yd<sup>2</sup>. The layers were consolidated into a composite flame-retardant nonwoven composite fabric by way of hydroentangling. Subsequently, the composite fabric was advanced onto a three-dimensional image transfer device so as to impart a three-dimensional pattern into the fabric. Table 1 shows the physical test results of the aforementioned fabric.



TABLE 1	
Composition	Sample A
ITD	Tricot
Weight	4.6 oz./yd <sup>2</sup>
Bulk	44 mils
Tensile MD-Peak (ASTM D-5035)	80 g/cm
Tensile CD-Peak	48 g/cm
MD Elong.	29.2%
CD Elong.	94.4%
Elmendorf Tear-MD (ASTM D-5734)	3178 g
Elmendorf Tear-CD	2087 g
Air Permeability (ASTM D-737)	147 cfm
Absorbency	7 sec
Thermal Shrinkage, MD (FNA-LB-WI-GL-136)	-1.0
Thermal Shrinkage, CD	-1.0
Modified Vert. Burn	
BFT Flame test	17.1

From the foregoing, it will be observed that numerous modifications and variations can be affected without departing from the true spirit and scope of the novel concept of the present invention. It is to be understood that no limitation with respect to the specific embodiments illustrated herein is intended or should be inferred. The disclosure is intended to cover, by the appended claims, all such modifications as fall within the scope of the claims.